Adaptive Control of Object Grasping by Manipulators, Considering Slippage in End-Effector

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***Abstract*— In this paper, we address the problem of adaptive control of a robot manipulator grasping an object, considering slippage in the end-effector. First we present a new approach to analyze system dynamics. Then we propose a controller that ensures the asymptotic convergence of object position to its desired value and slippage velocity to zero. Next due to advantage of the new dynamical model, we propose a simple update law to compensate uncertainties. We show analytically and numerically that the adaptive controller enforces the object asymptotically to converge to the desired trajectory and estimates good bounded values for unknown parameters while it reduces undesired slippage velocity to zero.**

I. Introduction

DUE to considerable abilities of multi robot systems such as large payload robot weight ratio, redundancy, and high rigidity, and also due to increasing industrial needs, there has been a great interest in using these systems, in the past two decades. Grasp planning is one of the important issues in the design and analysis of these systems. One has to find appropriate conditions for grasping while increasing system dexterity. Most researches in grasp analyses have assumed fixed point contacts in the finger tips [1]-[4]. However, there are some practical cases where we can not work with this assumption. In these cases we might have rolling or sliding contact. Some works can be addressed in literatures where the authors studied rolling contacts and developed kinematics and control laws for this case, [5]-[7]. Sliding contacts usually have been studied for regrasping of the object in maneuver of multi-fingered manipulators. Brock performed analysis of controlled slipping of an object within a robot hands by finding the constraint state as a function of a number of controllable variables such as grasping force and external applied forces [8]. Cole and Shankar used sliding contacts for regrasping in a two robot arm system [9]. They assumed a single contact point in the finger tip and considered only one finger for sliding. The sliding finger and its desired path are known in advance in their work. Zheng et. al. developed dynamic control of a three-fingered hand manipulating an object in 3D space, allowing one of the fingers to slide in the desired path [10]. In fact they have also studied regrasping using the same assumptions as those of Cole and Shankar.

Undesired slippage can occur during the grasping maneuver due to many reasons, such as changes in the object geometry, friction coefficient, etc. Grasp planning, in the presence of undesired slippage in end-effector as well as system parameter uncertainty is an interesting issue where has been received a little attention in object grasping analysis by multi-fingered manipulator. In this paper, first a new approach for analysis of dynamics of moving an object on a surface by a single finger mechanism is studied considering undesired slippage condition. The system under consideration is a platform for further extension to grasping analysis of a cooperative manipulator carrying out an object while slipping condition can occur. The new approach is based on a new contact condition modeling. Next we propose a controller that ensures the asymptotic convergence of object position to its desired value and slippage velocity to zero while compensates the uncertainties in the system parameters.

II. Equations of Motion

The system under consideration consists of a two-link rigid arm which moves an object on the horizontal surface. Contact between the manipulator and the object is assumed to be frictional pint contact (FPC). A schematic of the system can be shown in Fig. 1.

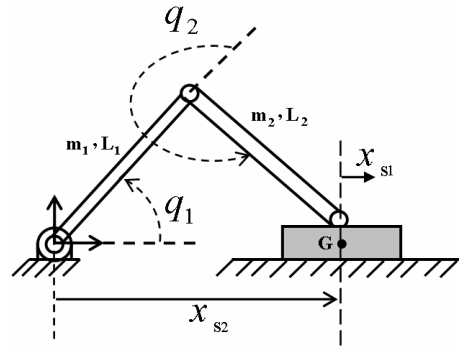

Fig. 1. Schematic of the system under consideration

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